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EVALUATION ON USING WEATHER DATA FROM CITIES LISTED IN THE NBR 16401 FOR AIR CONDITIONING DESIGN IN NON-LISTED CITIES

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Abstract. *This paper aims at evaluating the utilization of weather data from cities listed in the standard NBR-16401-1 to calculate the thermal load of buildings located in cities not listed by it, following the criteria established by that standard for finding among the cities listed, that whose climatic parameters are the closest to the project city. The thermal load of the same building was calculated with the aid of HAP software, 7.1 version from Carrier, using climatic data from the Test Meteorological Year of the project and the listed cities, design criteria provided by the standard and design criteria for non-listed cities calculated from the Test Meteorological Year using the Normal probability distribution. The results obtained for the design typical day were compared to evaluate possible differences between them. This process was repeated for five pairs of different cities, with the aim of expanding the study sample, making it more comprehensive. It was concluded that, in most cases, but not for all, to use the weather data provided by the standard for calculating the thermal load of buildings in non-listed cities is a good approximation.*

Keywords*: Air conditioning, climatic data, weather data*

1. INTRODUCTION

Air conditioning systems are designed based on the thermal loads of buildings. The Brazilian standard NBR 16401 (ABNT, 2008) recommends that the thermal load calculations are as accurate as possible, in order to make use of lower safety factors.

Thermal load calculation accuracy depends on the quality of information available, including the climatic conditions from where the building is located.

The NBR-16401 (ABNT, 2008) follows the meteorological data processing method from ASHRAE (2013) and provides climatic data for 34 Brazilian cities. It recommends that if the project city is not present, to adopt data from the city listed whose climatic parameters are the closest, hereafter referred as the corresponding city.

This manuscript aims to evaluate how using climatic data from the corresponding city instead of the project city, influence the results of thermal load calculations.

2. MATERIALS AND METHODS

As only cooling systems are focused in this investigation, the design parameters of interest are the dry bulb temperature (DBT) and the coincident wet bulb temperature (CWBT).

To evaluate the thermal load variation exclusively due to changing the building location, all internal heat sources, building envelope properties and facade orientations have remained constants.

Due to the complexity of the thermal load calculations, since they should take into account the simultaneity occurrence of all sources of heat loads as well as the dynamic effect of the building mass, it was necessary to use the software Hourly Analysis Program (HAP) version 7.1, developed, licensed and marketed by Carrier, destined to produce the complete profile of the thermal load of a building and to analyze the energy consumption of the air conditioning system (Carrier, 2016).

Teresópolis (RJ), Resende (RJ), Itiruçu (BA), Montes Claros (MG) and João Pessoa (PB) has been chosen as study cases, since they do not have weather data in NBR 16401 (ABNT, 2008). Then, following criteria defined in that standard, the corresponding cities were identified. These criteria are: both cities must be located in the same Brazilian bioclimatic zone presented in NBR 15220 (ABNT, 2005), have close altitudes and the same warmest and coolest months. These last information were obtained from the Brazilian climatologic normal files from 1961-1990 (INMET, 2009). Figures 1 to 5 show monthly average temperature from the project and corresponding cities, respectively Teresópolis (RJ) and Belo Horizonte (MG), Resende (RJ) and Londrina (PR), Itiruçu (BA) and Goiânia (GO), Montes Claros (MG) and Campo Grande (MS), and João Pessoa (PB) and Natal (RN).

Figure 1 – Monthly average temperature: Teresópolis and Belo Horizonte.

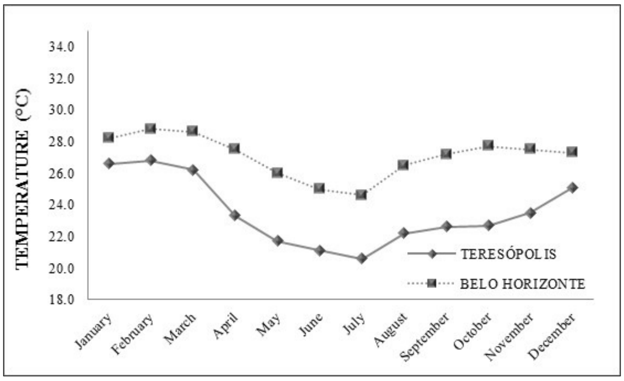


Figure 2 – Monthly average temperature: Resende and Londrina.

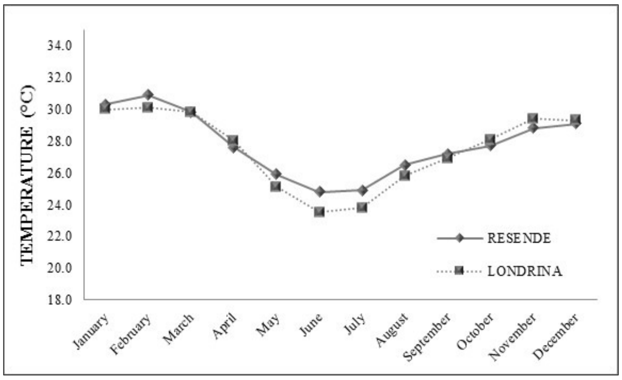


Figure 3 – Monthly average temperature: Itiruçu and Goiânia.

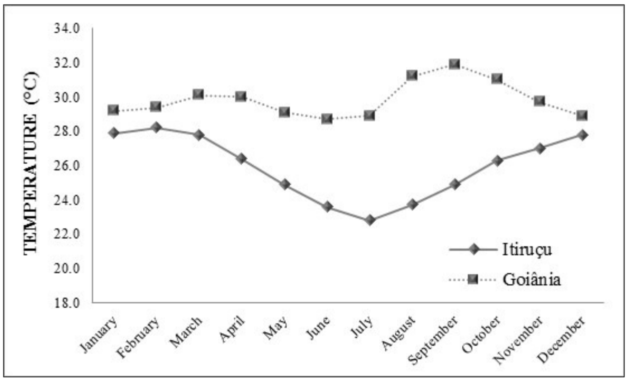


Figure 4 – Monthly average temperature: Montes Claros and Campo Grande.

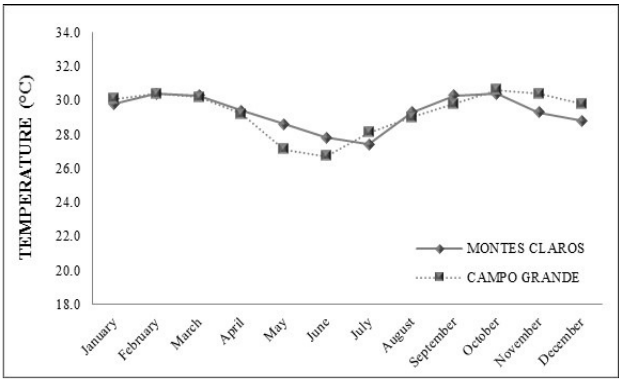
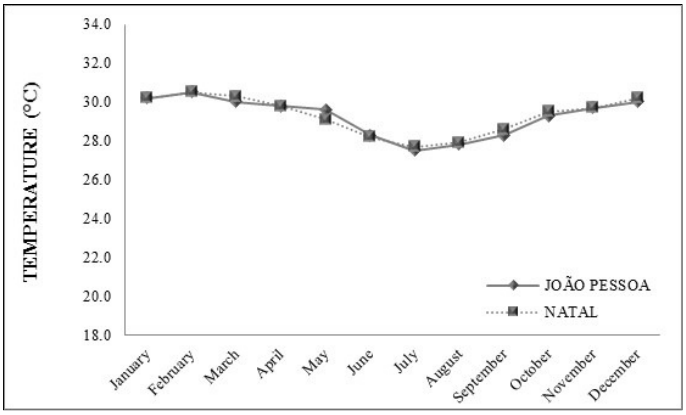


Figure 5 – Monthly average temperature: João Pessoa and Natal.



According to ASHRAE (2013), the design conditions result of an extensive database obtained by direct measurement of several variables, hour by hour, during a period of at least eight years. This database goes through statistical treatment to turn into a set of climate data, that can be used to design practical purposes. The DBT is the temperature that is only matched or exceeded by a specific percentage of the total number of hours of the year corresponding to the desired level of frequency. While the CWBT is the average of the wet bulb temperatures that occur simultaneously with the DBT calculated.

Typical Meteorological Year data (TMY) is an arrangement of selected climatic data for a given site, created from an extensive weather database. It is generated in order to present the range of weather phenomena, while still giving annual averages that are consistent with the long-term averages. According to Carlo (2005), the reference year set by TMY is formed by months that do not have extremes of temperature, but represent the typical climate behavior at the site of the building. The Energy Plus Weather (EPW) files are TMY files, available in the input format for the Energy

Plus software. The Energy Plus software was developed by the Department of Energy of United States to carry out energy building simulations (U.S. Department of Energy, 2015).

The thermal load of the building was calculated by four different methods as presented below:

- NBR: climatic data entered in HAP were provided by the NBR 16401 (ABNT, 2008) for the corresponding city at the frequency level of 1%.
- Calculated project data (CPD): climatic data entered in HAP come from the EPW files for the project city. The design DBT was found assuming Normal probability distribution and determining the temperature that corresponds to the frequency level of 1%. The design CWBT was that matched the average of the wet bulb temperatures that occur simultaneously with the DBT calculated.
- EPW for the corresponding city: the thermal load was calculated throughout the 8760 hours of the year using the EPW files of the corresponding city as HAP input.
- EPW for the project city - the thermal load was calculated throughout the 8760 hours of the year using the EPW files of the project city as HAP input.

For the two last methods, the day with the thermal load peak was assumed as the typical design day. The DBT and the dew point temperature (DPT) for this day were obtained directly from the EPW file.

For the CPD method, the Normal distribution assumption for DBT from EPW files is supported by all plotted frequency distribution shapes, although chi square goodness fit tests have rejected it for all cases.

3. RESULTS AND DISCUSSIONS

For each pair of correlated cities, two graphs were developed presenting respectively the DBT and thermal load of the typical design day, obtained using the four methods mentioned above. Figures from 6 to 15 show these graphs.

3.1 Teresópolis and Belo Horizonte

Figure 6 – DBT profile for the typical design day: Teresópolis and Belo Horizonte.

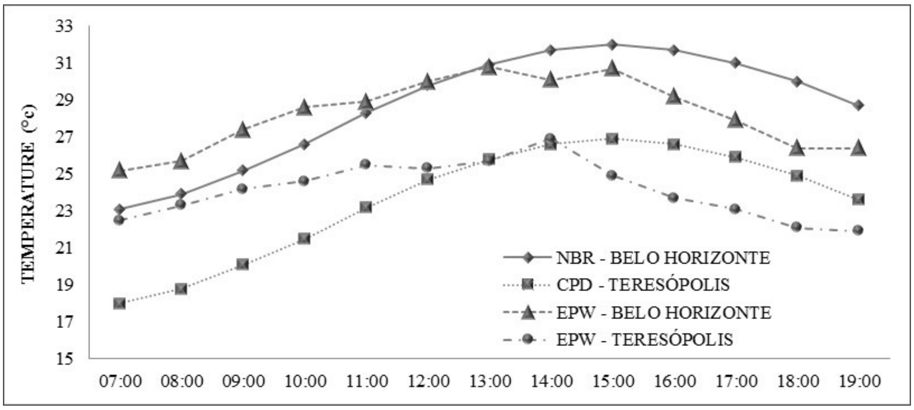
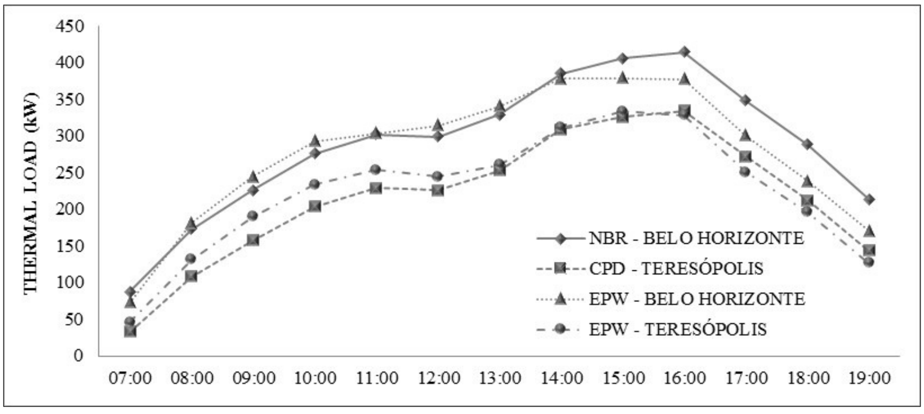


Figure 7 – Thermal load profile of the typical design day: Teresópolis and Belo Horizonte.



It can be seen in Figures 6 and 7 that both temperature and thermal load are remarkable higher for Belo Horizonte, showing that climate data from Belo Horizonte are not suitable for Teresópolis.

3.2 Resende and Londrina

Figure 8 – DBT profile for the typical design day: Resende and Londrina.

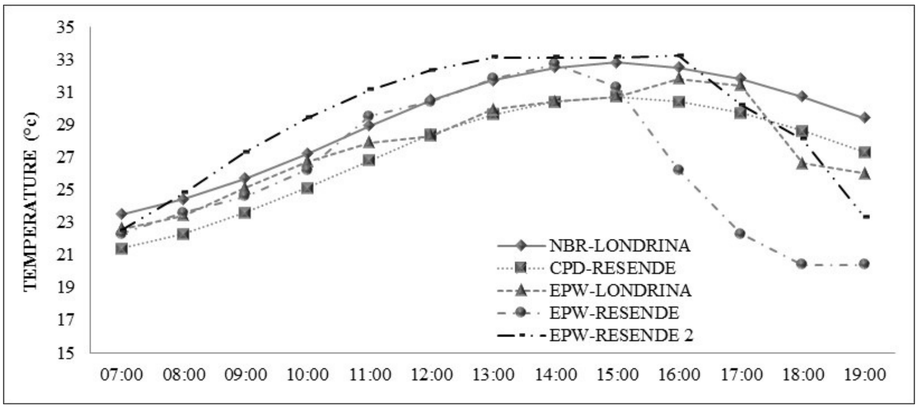
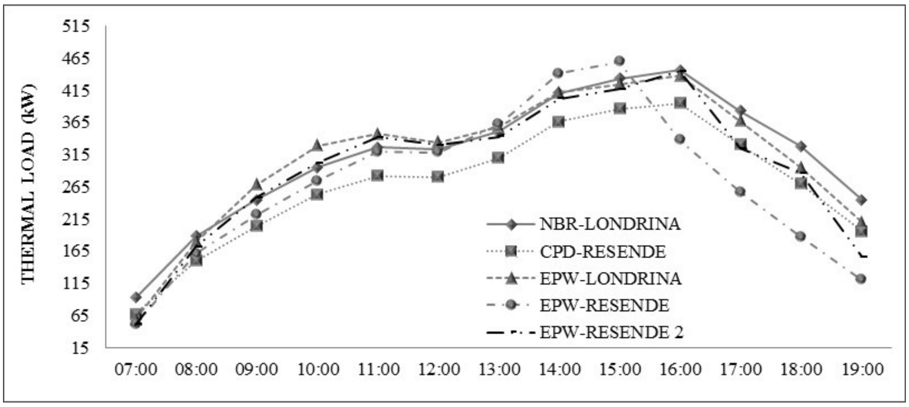


Figure 9 – Thermal load profile of the typical design day: Resende and Londrina.



It can be noted in Figures 8 and 9 that both Resende EPW plots have shown unexpected profiles with accentuated drop after 3 p.m. So, it was needed to select a new design day, that in which the second largest thermal load has occurred.

The new plots, indicated as EPW-RESENDE 2 in Figures 8 and 9, present usual profiles, allowing more reliable comparisons. It can be seen in Figure 9 that there is no significant difference among all thermal load plots, after disregarding the above mentioned atypical day. This indicates that Londrina data can be used for Resende.

3.3 Itiruçu and Goiânia

Figure 10 – DBT profile for the typical design day: Itiruçu and Goiânia.

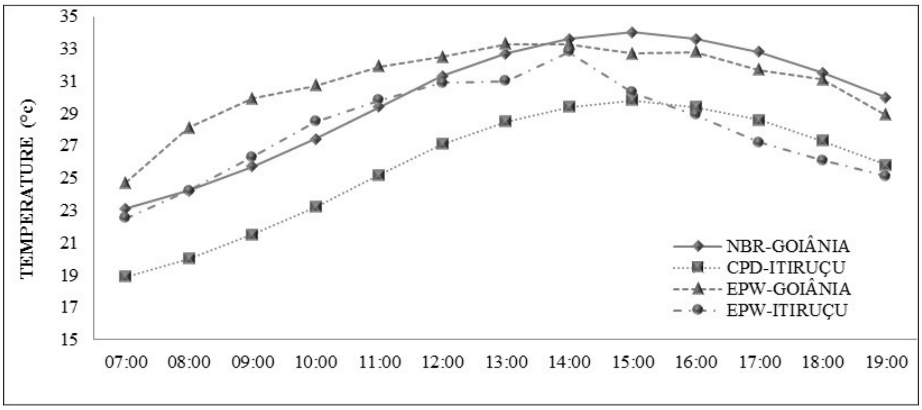
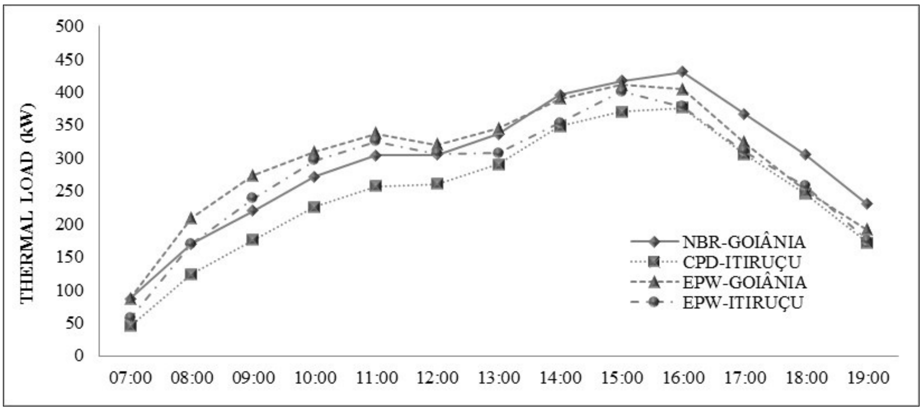


Figure 11 – Thermal load profile of the typical design day: Itiruçu and Goiânia.



The design day generated from the EPW files for the corresponding and the project cities, respectively December, 18th and March, 12nd, belong to different seasons. So, the differences found between the EPW results are probably due to solar radiation effects.

Although Figure 10 shows a temperature difference between CPD-ITIRUÇU and NBR-GOIÂNIA, Figure 11 shows that this difference is reduced in the corresponding thermal load plots, probably because both CWBT are close.

In addition, Figure 3 shows that monthly average temperatures are close for both cities on the summer months. It is concluded that climatic data from Goiânia can be used to Itiruçu.

3.4 Montes Claros and Campo Grande

Figure 12 – DBT profile for the typical project day: Montes Claros and Campo Grande.

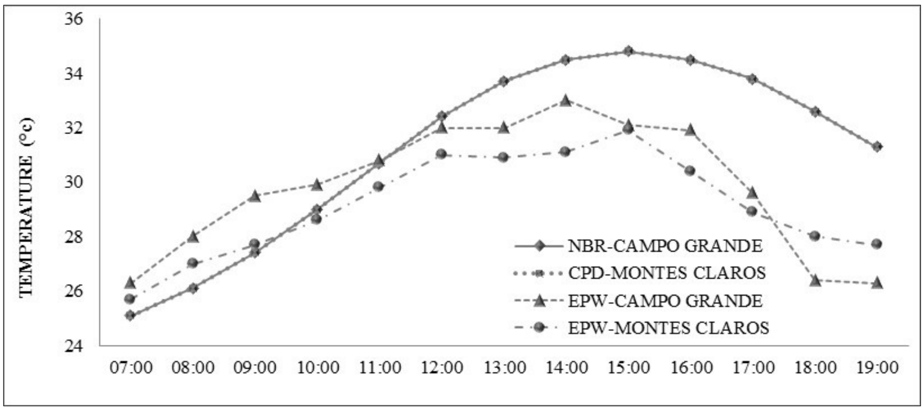


Figure 13 – Thermal load profile of the typical project day: Montes Claros and Campo Grande.

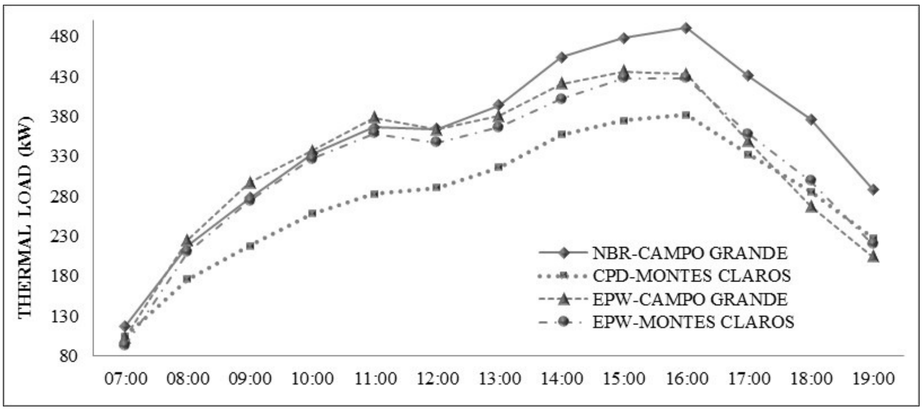


Figure 12 shows that DBT CPD-MONTES CLAROS plot coincides with NBR-CAMPO GRANDE plot. However, Figure 13 shows that thermal load plots correlated to them differ approximately by 22%. This can be explained since CWBT for Campo Grande is 5.3 degrees Celsius above that for Montes Claros.

Although epw temperature and thermal load plots for both cities are close, the difference in the CWBT between these cities become inappropriate to use data from Campo Grande for Montes Claros.

3.5 João Pessoa and Natal

Figure 14 – DBT profile for the typical design day: João Pessoa and Natal.

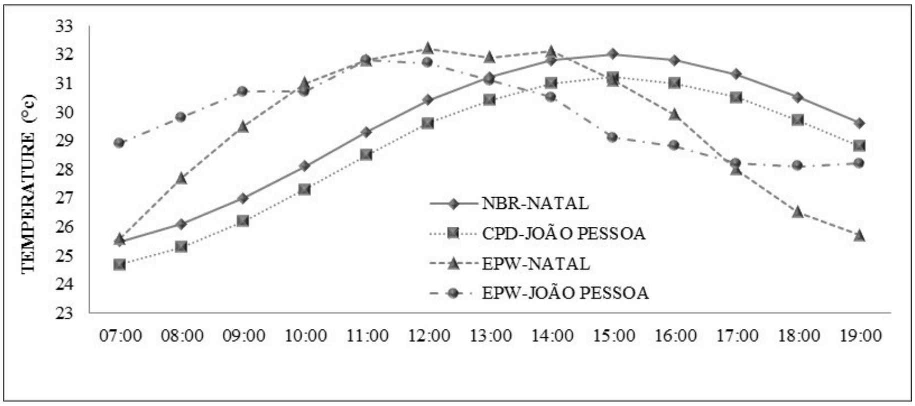
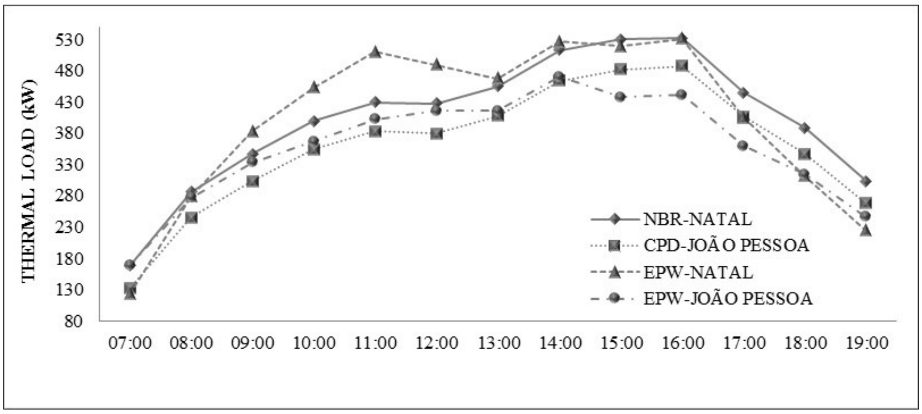


Figure 15 – Thermal load profile of the typical design day: João Pessoa and Natal.



Although the NBR 16401 (ABNT, 2008) states that Natal`s hottest month is February, both the first and the second largest thermal load days found by the EPW method are in the winter, respectively August, 16th and 08th.

In Figure 15, the thermal load peak difference between NBR-NATAL and EPW- JOÃO PESSOA is 11.69%, much higher than that presented between the NBR-NATAL and EPW-NATAL plots. Thus, it is inappropriate to say that data from Natal can be used for João Pessoa.

However, Figure 5 shows that Natal and João Pessoa have similar climates, so probably data from Natal could be used for João Pessoa. It is concluded that this case study was hampered due by the Natal EPW file available.

3.6 Searching for an acceptance criteria

The DBT means calculated from NBR 16401 (ABNT, 2008) tables using the Normal probability distribution, were higher than those calculated from the EPW files, for all corresponding cities. Thus, it can be supposed that during the generation of the EPW files, the hottest months had been eliminated much more frequently than the cooler ones.

In the current situation of global warming, months with high extreme temperatures have predominated and therefore they have most often been eliminated when following the methodology for generating the EPW files. If the EPW data generation were able to freeze the original temperature mean, it was expected that EPW temperature means were higher because they were prepared taken into account the period from 2001 to 2010 while NBR data have used the period from 1982 to 2001.

For this reason, all NBR data were above the CPD data. Table 1 shows the DBT and CWBT differences calculated by the NBR and CPD methods.

Table 1 – Decision criteria

Cities	DBT difference between NBR and CPD (°C)	CWBT difference between NBR and CPD (°C)	Decision
Belo Horizonte - Teresópolis	5.1	1.6	No
Londrina – Resende	2.1	1.3	Yes
Goiânia – Itiruçu	4.2	0.6	Yes
Campo Grande – Montes Claros	0.0	5.3	No
Natal – João Pessoa	0.8	1.5	Yes

Thus, when the DBT and CWBT differences are less than pre-established values to be determined in a later study, the data from the corresponding city can be used for the project city.

4. CONCLUSION

From the thermal load calculation methods presented in this study, it was possible to evaluate, for each project city, the influence of using corresponding city weather data in the thermal load calculations.

It was supposed that in the generation of EPW files, the warmer months were deleted more frequently, justifying the difference found between the NBR and CPD methods. It is proposed that this difference is used as a decision criterion.

Thus, it can be concluded that in the majority of cases, using the weather data provided by the NBR 16041 (ABNT, 2008) standard for calculating the thermal load of buildings in not listed cities is a good approach.

The authors have not found any paper related to this theme in the open literature, so they expect that this paper serves as a stating point.

5. ACKNOWLEDGEMENTS

The authors thanks Escritório Integrado de Engenharia Auxiliar Ltda for allowing to use the HAP software.

6. REFERENCES

ASSOCIAÇÃO BRASILEIRA DE NOMAS TÉCNICAS - ABNT, 2008. NBR 16401-1: Instalações de Ar Condicionado – Sistemas Centrais e Unitários. Parte 1: Projeto das instalações. Rio de Janeiro, RJ, Bazil.

ASSOCIAÇÃO BRASILEIRA DE NOMAS TÉCNICAS - ABNT, 2005. NBR 15220-3: Desempenho térmico das edificações -Zoneamento bioclimático brasileiro e diretrizes construtivas para habitações unifamiliares de interesse social. Rio de Janeiro, RJ, Brazil.

American Society of Heating, Refrigerating, and Air-Conditioning Engineers - ASHRAE., 2013. Handbook Fundamentals. Chapter.14. Climatic Design Information. Atlanta, GA, USA.

Carlo, J. C., 2005. Processamento de arquivos climáticos para simulação de desempenho energético de edificações. Universidade Federal de Santa Catarina, Florianópolis, SC, Brazil

CARRIER, 2016. Hourly Analysis Program. Available in: <https://www.carrier.com/commercial/en/us/software/hvac-system-design/hourly-analysis-program/>. Accessed in: 07 jan. 2016.

INSTITUTO NACIONAL DE METEOROLOGIA - INMET, 2009. Normais Climatológicas do Brasil 1961-1990. Available in: <http://www.inmet.gov.br/portal/index.php?r=clima/normaisClimatologicas>. Accessed in: 10 nov. 2014.

U.S. Department of Energy, 2015. EnergyPlus Energy Simulation Software. Available in: <http://apps1.eere.energy.gov/buildings/energyplus/?utm_source=EnergyPlus&utm_medium=redirect&utm_campaign=EnergyPlus%2Bredirect%2B1>. Accessed in: 07 jun. 2016.

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